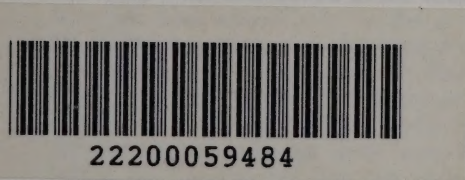


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RECENT EXPERIENCES OF THE UNITED STATES ARMY
WITH REGARD TO SANITATION OF YELLOW FEVER
IN THE TROPICS

W.C.Gorgas

The Journal of Tropical Medicine,
1903, 6.



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University of Leipzig, but has been attached to the School of Medicine in Cairo for some five years, in order to carry out research work in connection with Egyptian parasites. The collection is most interesting, not only from a purely helminthological point of view but also from a clinical standpoint. Many new parasites discovered by Professor Looss while working in Egypt were exhibited with good typical specimens of all the more generally known species, including filaria, ankylostoma, and others. These specimens are all beautifully displayed and mounted.

We cannot conclude without expressing our admiration at the pitch of excellence to which the glyceriformol method has attained in the hands of Dr. Symmers, the Professor of Pathology to the School. The specimens are all beautifully mounted, and could not be improved upon for the use of students and for demonstrative purposes.

RECENT EXPERIENCES OF THE UNITED STATES ARMY WITH REGARD TO SANITATION OF YELLOW FEVER IN THE TROPICS.

By Major W. C. GORGAS, Medical Corps U.S. Army.

Paper read before the Egyptian Medical Congress.

THIS being the section devoted to tropical diseases, I have thought that some account of the original investigations made concerning one of these diseases, and of the sanitary work carried out as the result of these investigations in the tropical island of Cuba by the United States Army, might be of interest to the section.

While our sanitary work in Cuba was on general lines, the particular interest in this work and our efforts were centred upon yellow fever; and for very obvious reasons. Yellow fever is the only one of the severe epidemic diseases to which the Western continent has been subject to any extent. While cholera has spread in most parts of this continent, its ravages have not been at all comparable to those of yellow fever, and the plague has never affected the Western continent to any extent. Yellow fever, on the other hand, has ravaged both continents many times; on the eastern shore, from Quebec on the north to Montevideo on the south, and for long distances on the western shore; and within these limits the destruction of life caused by its prevalence has been second only to the great losses caused by cholera and plague in the large European centres; sometimes, in as large a city as Philadelphia, killing one-third of the population present at the time of its prevalence. It has been particularly fatal where large numbers of non-immunes have been brought together within the Tropics, and this has made it the dread of military commanders in these regions. In this respect it has been more certainly fatal than cholera or the plague in the East. Military expeditions in the Tropics in the past have been almost certain to suffer from this disease, and there have been several instances of large bodies of men being almost entirely swept off, and the objects of the expedition frustrated, by this disease alone; as the French expedition in 1802 to Haiti, in which, out of 25,000 men, nearly 22,000 died of yellow fever in one season, leaving the remainder entirely at

the mercy of the enemy, who scarcely had to fire a shot.

To the United States for the last generation yellow fever has been particularly important, not only on account of the loss it has caused to the population, but on account of the great financial loss caused by the quarantines, which were established all over the country when this disease appeared in epidemic form; and of late years along our southern coast these quarantines are established every summer to prevent the introduction of the disease from the neighbouring coast of the Gulf of Mexico. It is estimated, for instance, that the financial loss caused to the Mississippi valley by the last great epidemic of 1878 amounted to not less than 100,000,000 dollars.

The origin of this disease, as that of all others, is shrouded in obscurity. We have pretty good evidence that it existed among the Indians on the Mexican coast before the landing of Cortez, and since that time it has been continually present in the West Indies and the coast bordering the Gulf of Mexico and the Caribbean Sea. Occasionally it spreads from this, its constant home, and about the beginning of the nineteenth century it looked as if it might become one of the great epidemic diseases of the world. It made its ravages at that time in Spain, France and Italy, and all along the eastern inhabited coast of North and South America. It has never been known in the densely-populated countries of China and India, or any part of Asia or Australia.

I will not go into the symptomatology more than to say that yellow fever is a febrile disease of about a week's duration, with well-marked and characteristic symptoms in the pronounced cases, and, as in other febrile diseases, shading off into every variety of mildness in character. A great deal of study has been given to yellow fever, and the peculiarities as to its mode of spread, its history and symptomatology, are very well known. At the time of the outbreak of the Spanish-American war, the following facts with regard to the disease had been pretty well settled and generally received: That it was endemic about the Gulf of Mexico as stated above; that outside of its endemic focus it was not found unless imported there in some way; that a temperature below the freezing point almost always caused its disappearance; that it could not be communicated directly from person to person. It was universally received that it was transmitted to fomites, and it was well known that a sick person or fomites introduced into a non-infected house would not at once infect it, but that a considerable length of time had to intervene between the introduction and the infection. That, for instance, a man sick of yellow fever, if introduced into an unaffected house, could be nursed with entire safety by a non-immune, but that in the course of time this house would become dangerous, from the fact of the yellow fever patient having been there, and that after this time a non-immune was liable to contract yellow fever from merely entering the house. It was known that heat and moisture were very favourable for its development; that it did not occur above certain altitudes; that non-immunes could escape the disease entirely by leaving an infected town, and that they did not, as a general thing, carry the disease with them.

At the outbreak of the Spanish-American war Havana was generally believed to be the principal endemic focus in the Western continent. The disease was known to never have been absent from this city for the past 150 years. And it was the point from which all the surrounding countries were being constantly reinfected. The States of the Union lying along the Gulf of Mexico were in particular danger from this source, and the yellow fever of Havana was looked upon as costing these States the loss of many millions of dollars yearly. From the experience of Spain and other European nations in sending large bodies of troops to the West Indies, and from the experience of the English in India and their East Indian Possessions, the United States military authorities looked with anxiety upon our expeditions into Cuba, and feared a very large mortality from disease, and particularly from yellow fever. We had long been accustomed to protect our small garrisons from yellow fever when epidemic in the southern States by moving the garrison a few miles from the infected locality. This was almost invariably successful, and in a few cases in which the first move was not successful a second would be, if care were taken to remove those who sickened in the first few days. But an army undergoing active military operations is not always able to do this, and we know that, on account of the large body of Spanish soldiers present, nearly every part of the island was infected by yellow fever.

In taking possession of Havana, our principal sanitary object was to get rid of yellow fever. We believed that the cities on the eastern coast of the United States, such as Boston, New York, and Philadelphia had ceased to be subject to yellow fever, on account of their improved sanitary condition. We therefore hoped that we would get rid of yellow fever, or at least greatly decrease it, by placing Havana in good sanitary condition; hence we promptly set about this work. Liberal appropriations of money were made for the purpose, and every measure that sanitary science of that day could suggest was adopted. Of course I refer to more or less temporary measures. We knew that we would not have time for an extensive system of sewerage, or any such permanent improvements. So far as the general mortality of the city population was concerned the results obtained by these methods were very gratifying. The death-rate, which in 1898—the last year of the war and of Spanish occupation—was 91·03, fell in 1899 to 33·67, in 1900 to 24·40, and in 1901 to 22·11, a rate which compares favourably with the rates of the more civilised cities of Europe and America; but, to our chagrin and disappointment, we apparently had no effect upon yellow fever.

We had gone to Cuba with the idea that yellow fever was a filthy disease; that its germ developed in decomposing organic matter. We had hoped that if we thoroughly cleaned up Havana we would deprive the city of the culture medium in which the yellow fever developed, and thus rid it of the disease itself; but we found that, while we had little or no yellow fever in the early part of 1899, it began to increase very rapidly after August of that year, when a large non-immune Spanish immigration began to pour in, and December of 1899 was one of the worst Decembers for this disease

ever recorded in Havana. During 1900 the sanitary conditions of the city, as evidenced by the general death-rate, continued to improve. Yellow fever, on the contrary, grew worse and worse, and 1900 was one of the severest epidemic seasons, even for Havana, which had been recorded for the preceding 140 years. The best and most cleanly parts of the city were most affected. The Sanitary Department had now had two years of most careful cleaning, disinfection and isolation of yellow fever, without having any perceptible effect, and I became convinced that the disease could not be eradicated on these lines alone.

Early in 1900 a Board of Army Medical Officers, of which Major Walter Reed was president, was sent to Havana for the purpose of studying yellow fever. After working on various lines they determined to study the mosquito with reference to the disease. They were led to this determination for several reasons, as stated in their "Preliminary Note," more particularly by the well-known epidemiological course of the disease, by the work of Ross, on the transmission of malarial fever by the mosquito, and by the report of U. C. Carter, Marine Hospital Service, U.S.A., on the interval between the infecting and secondary cases of yellow fever. They established an experimental station in the country and half-a-mile or more from any habitation, placed non-immunes in this camp under military control, so that they could not leave it, kept them there a sufficient length of time to be certain that they had not contracted yellow fever, and then experimented upon them with the species of mosquito which, Dr. Finlay maintained, propagated yellow fever. Dr. Carlos Finlay is an eminent physician of Havana, who has been writing and maintaining ever since 1881 that a certain species of mosquito in Havana was the means of transmitting the disease from person to person. Dr. Finlay had made many experiments with the mosquito, but the results obtained by him were such that they were not anywhere accepted as proving his contention.

The Army Board, after considerable experimentation, found that they could take a *Stegomyia*, let it bite a yellow fever patient within the first three days of the disease, keep the mosquito from twelve to twenty days, let it bite a non-immune, and almost invariably transmit the disease. They had some eighteen cases transmitted in this way. The fact that the disease so transmitted was yellow fever was established not only by well-marked symptoms, but by having well-known physicians of Havana see the cases, and also having them diagnosed by the official board of Havana, which diagnosed all cases occurring in that city. The following year the Sanitary Department, in an endeavour to immunise, had patients bitten by infected mosquitoes. An autopsy held in a fatal case occurring in these experiments confirmed the diagnosis in every respect. But the symptoms of yellow fever are so pronounced in a case at all severe that there is ordinarily but little doubt about it.

As above described, the Board had taken the precaution to isolate the men experimented upon, so that they could contract the disease in no other way. At the same time that these experiments were going on the Board had a mosquito-proof house built, in which they placed fomites of all kinds—clothing, bedding, and all

things soiled by yellow fever patients. In this building non-immunes slept for two weeks, were then taken out, kept for two weeks longer in the camp, bitten by the mosquito, and promptly developed yellow fever. The period of incubation was found to be from three to six days, the shortest time being two days and twenty-two hours, and the longest six days and two hours. The Board also found that the disease could be transmitted by injection of the blood of patients suffering from yellow fever taken within the first three days of the disease.

The incubation period in one of these blood cases was slightly under forty-eight hours. They also found that the blood, after being passed through a filter which would stop all known micro-organisms, still retained the quality of transmitting the disease, tending to prove that the micro-organism which causes the disease is still sub-microscopic.

These investigations of the Board of Army Medical officers convinced the Sanitary Department that the *Stegomyia* mosquito was the only way of propagating yellow fever, and that fomites played no part whatever in its transmission. Granting these conclusions as facts, it was evident that if we could get rid of the infected *Stegomyia* and prevent any more *Stegomyia* from becoming infected, we would get rid of yellow fever. With these objects in view a scheme was worked out:—

First, to prevent mosquitoes biting people who had contracted yellow fever. For this purpose arrangements were made so that the quarters of a patient were screened with wire netting, within two hours after the case was reported, and a guard placed over the quarters to see that the one wire door allowed was kept properly closed. Immunes were freely allowed to pass, and no notice was taken of fomites of any kind.

Secondly, to kill all mosquitoes that might have become infected before the screening of the patient. For this purpose arrangements were made to kill all mosquitoes, both in the house occupied by the patient and in all the contiguous houses. Each room was carefully closed and sealed, just as if formaline was going to be used, and pyrethrum burnt in the room, at the rate of a pound to 1,000 cubic feet of space. Pyrethrum powder, while not the best insecticide, was found to do less injury than other substances, but care was taken to sweep mosquitoes up after its use and destroy them, as a considerable portion of them would revive when exposed to the fresh air.

Thirdly, arrangements were made to keep out people suffering from yellow fever, either in its active or incubative stage. On the sea-side this was managed by a five-day quarantine maintained by the Marine Hospital Service. On the land side we had a system of inspection by which all non-immunes were reported, registered, and seen daily by a physician for six days. During the latter six months of 1900 Havana admitted from the infected towns around her, on the land side, some 1,200 non-immunes. From these 1,200 non-immunes we picked up some twenty odd cases of yellow fever. Business and travel did not appear to be interfered with in the least, and no attention whatever was given to traffic or the introduction of fomites of any kind. The system was entirely satisfactory, and I believe could be adopted to advantage in all similar cases.

Fourthly, brigades were organised for the destruction of mosquito larvæ in all parts of the city and suburbs. This was the part of the work on which we put the most labour, and that cost us most.

We modified our original system considerably, as we learned the habits of the different species of mosquitoes, and found the ways whereby our labour could be most advantageously expended. We were very successful in decreasing the numbers of mosquitoes. By the end of 1901 they were much less numerous in all parts of the city, and in many parts had entirely disappeared. In January, 1901, just before the mosquito brigades were organised, an inspection was made of the whole city, and it was found that mosquito larvæ existed in 26,000 different deposits in the city. The inspection made in January, 1902, when the mosquito brigades had been at work about ten months, showed less than 300 deposits of larvæ in the same area. The effect of the mosquito destruction can be well measured by the death-rate from malaria. In 1900 this was 344; in 1901, 151; and up to July, 1902, 47.

The results as to yellow fever were complete. From the institution of these measures yellow fever began rapidly to decline. Each focus was entirely destroyed as it appeared, and gave no more trouble. The work was commenced in February, 1901, and on September 28th of the same year the last case of yellow fever, occurred in Havana. Since that time—now more than a year—not a single case has originated in the city. As evidence that this is not accidental, I here insert a table of the deaths from yellow fever for the last twelve years:—

DEATHS FROM YELLOW FEVER ACCORDING TO YELLOW FEVER YEAR.

Years	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	Average	1901	1902	1903
Months																
April	13	5	8	8	4	6	14	71	1	2	0	12-00	0	0	0	
May	23	7	7	23	16	10	27	88	4	0	2	18-81	0	0	0	
June	38	41	13	69	31	16	46	174	3	1	8	40-00	0	0	0	
July	67	66	27	118	77	88	116	168	16	2	30	70-45	1	0	0	
Aug.	60	66	67	100	73	120	262	102	16	13	49	84-36	2	0	0	
Sept.	33	65	70	63	76	135	166	56	34	18	52	70-27	2	0	0	
Oct.	32	48	54	46	40	102	240	42	26	25	74	66-27	0	0	0	
Nov.	15	24	52	28	23	35	244	26	13	18	54	48-36	0	0	0	
Dec.	9	17	33	11	29	20	147	8	13	22	20	29-90	0	0	0	
Jan.	10	15	15	7	15	10	69	7	1	8	7	14-90	0	0	0	
Feb.	3	10	6	4	4	7	24	1	0	9	5	6-63	0	0	0	
Mar.	4	1	4	2	2	3	30	2	1	4	1	4-90	0	0	0	
Total	307	365	356	484	390	552	1385	745	128	122	302	466-90	5	0	0	

A glance at this table will show that yellow fever has probably never been absent from Havana for a single day in all these years; that the smallest number of deaths occurring from this disease was 122, in the year 1899; the largest number, 1,385, in the year 1896; average, 466; and, as far as we can find from the records, the same condition of affairs has existed since 1762.

The same favourable condition of affairs was witnessed in the Army. The first year of our occupation, in 1898, with an average strength of 8,345, we had a death-rate from disease of 67-94; in 1899, with an average

strength of 11,969, we had a death-rate from disease of 17.29; in 1900, with an average strength of 8,690, we had a death-rate from disease of 8.40; in 1901, with an average strength of 5,297, we had a death-rate from disease of 3.21; and in the fiscal year ending June 30th, 1902, with an average strength of 4,187, we had a death-rate from disease of 1.43. The death-rate for 1902 was smaller than our death-rate from disease, either in the United states or any possessions of the United States.

A consideration of these facts will, I think, convince an unprejudiced reader that our great success in the preservation of the health both of our troops and the native population, in the entire extirpation of yellow fever, and the almost entire extirpation of malarial fever, was due to the destruction of and precautions against the mosquito, and that these measures would never have been instituted except for the discoveries made by the Army Medical Board.

